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## Nature of STEM

As Science, Technology, Engineering, and Math (STEM) education begins to develop shoots and roots in America's classrooms, educators must take a step back in order to look ahead. STEM in the education world has shifted from the SMET to STEM (McComas 2014), to a nationwide buzzword, to school projects and STEM fairs, and robust programs. As states begin to adopt the Next Generation Science Standards (NGSS Lead States 2013) it is critical to also pursue a deeper understanding of the nature of STEM fields as we prepare our students to be scientifically literate citizens. Although I am pioneering an integrated STEM program at my school, I will speak to the nature of science in this assignment as I am most familiar with the tenets of science.

### Reflection on Current Use of Nature of Science Tenets

New York City began playing with bite sized pieces of NGSS in 2014 which happened to be my first year of teaching. As I straddled the New York Learning Standards for Math, Science, and Technology (New York State Education Department 1996) alongside the drips and drops of NGSS through professional development I began to form the opinion that NGSS was significantly better than the previous set of New York standards. I began my first year teaching middle school science with a "unit 0" on the methods of science. We practiced using the metric system, discussing lab safety, and of course every step in the scientific method. In my second year of teaching I grew my understanding of the Science and Engineering Practices (SEPs) of the NGSS, wove them into a handful of activities and decorated my classroom with them.

Looking at my more recent years in the classroom, I have not explicitly taught the Nature of Science as stated in Appendix H of the NGSS however I have incorporated the SEPs and Crosscutting Concepts (CCCs) throughout my science curriculum which envelop the tenets of the Nature of Science. The McGraw Hill - Inspire Science curriculum generously purchased by the Parent Teacher Association at my school is NGSS aligned and incorporates 3-Dimensional Learning. The individual lessons in Inspire Science are built around performance expectations that incorporate the disciplinary core ideas as well as the SEPs and CCCs. As we moved through the curriculum students regularly saw learning objectives using the SEP and CCC language. The hands-on structure of the curriculum allowed students to naturally begin using the language of nature of science to discuss ideas, create investigations, and construct explanations about challenges they were presented with in class.

Looking back specifically on the electricity and magnetism unit, the science department fell into a pattern of heavily leaning into the SEP 3 - planning and carrying out investigations, SEP 6 - constructing explanations from evidence, and CCC 2 - cause and effect. Typically in a lesson we'd present students with a phenomena or a challenge, then they would be tasked with designing an investigation to test their ideas or to solve the challenge, given a list of criteria,

constraints, and materials. Students then would set off to plan and carry out an investigation, collect data, and ultimately construct an explanation, using the claim-evidence-reasoning (CER) template, of what happened in their investigation using their data and class readings as evidence. We typically asked students to utilize CCCs in their CER statements and often nudged them towards incorporating the CCC cause and effect.

This is not to say that we did a poor job implementing NGSS and aspects of the nature of science last year, however, looking back there were a lot of opportunities where we could have discussed the nature of science, explored other SEPs more deeply, and opportunities where we could have encouraged students to explore and make connections with other CCCs.

#### Considerations for Enhancing My Practice to Address the Tenet(s) In Appendix H

Just like the nature of science, my thinking and understanding of the nature of science is “open to revision in light of new evidence” (NGSS Lead States 2013). As mentioned earlier, my first year of teaching included an entire unit dedicated to the scientific method and a very linear view of the process of science. As I grew in my practice I stepped away from teaching “unit 0” the SEPs and CCCs became more fluid throughout lessons and units rather than isolated topics at the start of the school year. I would like to continue to lead lessons with a wider variety of SEPs and CCCs this year. Reflecting on my practice has allowed me to review and consider the ways in which I can better incorporate the nature of science as outlined in Appendix H of the NGSS.

To start, I intend to make clear to students this year that science is a human endeavor. I'd like to bring in more scientists, discuss them as people as well as their contributions to science in addition to developing a narrative in which students identify themselves as members of the scientific community. To quote myself from our week 4 discussion, teaching students that science is a human endeavor is, “a simple way to humanize the work of scientists and make the process of science and body of knowledge of science a little less sterile and more tangible.”

Science as a way of knowing is also an aspect I'd like to explicitly include in my classroom. After reviewing our week 6 readings on STEM, Indigenous Peoples, and Equity I am interested in incorporating different ways of knowing and understanding in science (Bang et al. 2015) (Bell et al. 2015). This idea in and of itself allows opportunity to explore the other tenets structured in scientific knowledge use, acquisition, and revision. In order to implement this idea of acknowledging and discussing how the body of knowledge in science is developed, collected, edited, and revised this year I'll need to include students' own stories and experiences with science knowledge both inside and outside of the classroom. It is crucial not to simply acknowledge students' prior knowledge we also need to think about the way our students engage with, think through, and experience the natural world (Larkin 2011).

Thinking towards building an integrated STEM program I will need to consider the other “nature of” technology, engineering, and math. In order for the STEM program to truly be integrated I have to actively shift my thinking from prioritizing the science discipline and open up to fully exploring the other STEM disciplines in my program (Koehler 2015). Luckily, there are

many connections between science, technology, engineering, and math which will make it easier to integrate all the disciplines.

### Overlap of the Nature of Science and the Nature of Technology

My reflection has been focused exclusively thus far on the nature of science since science education has been the focus of my teaching career. However, as I move towards teaching STEM I'm pushing myself to look beyond the nature of science by taking a step out of my comfort zone to compare the tenets of the nature of science to the tenets of the nature of technology as outlined in the Standards for Technological Literacy (ITEA 2007). The first three standards of technological literacy are collectively grouped as the Nature of Technology Standards (NOTS) and will therefore be used as such in our comparison between the nature of science (NOS) and the nature of technology.

The Nature of Technology Standards (ITEA 2007):

1. Students will develop an understanding of the characteristics and scope of technology
2. Students will develop an understanding of the core concepts of technology
3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields.

NOTS 1 overlaps with the NOS tenet science is a human endeavor. In both disciplines students begin to build upon the idea that advances in technology influence the progress of science and vice versa. We see overlap in identifying the qualities of scientists and engineers, both natures convey that science and technology rely on human imagination and creativity as well as precision, reasoning and logic. We also see overlap in the construction of science and technology, both have developed due to human activity and the needs of culture and society.

Another overlap occurs between NOTS 2 core concepts of technology and NOS tenets of scientific investigations use a variety of methods and science is a way of knowing. NOTS 2 focuses on specific core concepts of technology in a similar way that the nature of science is a broad body of core concepts for all areas of science. Both natures identify a path for engaging in inquiry and development of new ideas that involve systems, processes, values, and methods. In NOTS we see language such as, "different technologies involve different sets of processes" and, "particular steps that people perform" (ITEA 2007). Similarly we see in NOS "scientific investigations use a variety of methods" as well as "science is both a body of knowledge and the processes and practices used to add to that body of knowledge" (NGSS Lead States 2013). We see common rules in NOT and NOS in the form of processes, systems, and multiple methods in order to obtain knowledge.

Lastly, there is a bridge between in NOTS 3 where students look at relationships among technologies and the connections between technology and other fields while in NOS we see that scientific knowledge is cumulative and many people between nations and generations and science disciplines contribute to science knowledge. In NOS we have laws and theories that can be transferred between numerous settings in the same way that technology can fluidly move

through different fields. For example the technology of PCR (polymerase chain reaction machine) can be used in forensics, medicine development, and improving crops in agriculture. There are several opportunities for overlap in NOTS and NOS.

Through reflection of my own understanding and practice of the nature of science, it appears there is a need for professional learning communities focused on the weaving of the nature of science in classrooms. My new understanding is that the nature of STEM is a little less certain in comparison to the individual natures of science, technology, engineering, and math as separate disciplines. While there is subtle overlap between natures of the separate STEM subjects there is a clear need for the development of a nature of STEM (Peters-Burton 2014).

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